
State of California
The Resources Agency
Department of Water Resources

**MATRIX OF LIFE HISTORY AND
HABITAT REQUIREMENTS FOR
FEATHER RIVER FISH SPECIES
SP-F3.2 TASK 2**

HARDHEAD

**Oroville Facilities Relicensing
FERC Project No. 2100**



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Matrix Of Life History and Habitat Requirements for Feather River Fish Species - Hardhead
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Element	Element Descriptor	General	Feather River Specific
General			
common name (s)	English name (usually used by fishers and laypeople).	<p>Hardhead</p> <p>The origin of the name "hardhead" is obscure; in early literature, it applied to Sacramento blackfish, Sacramento pikeminnow, and other large minnows (Moyle 2002).</p>	
scientific name (s)	Latin name (referenced in scientific publications).	The scientific name of hardhead is <i>Mylopharodon conocephalus</i> (Moyle 2002).	
taxonomy (family)	Common name of the family to which they belong. Also indicate scientific family name.	Hardhead belong to the <i>Cyprinidae</i> (i.e., minnow) family (Moyle 2002).	
depiction	Illustration, drawing or photograph.		
range	Broad geographic distribution, specifying California distribution, as available.	<p>Hardhead are widely distributed in low- to mid-elevation streams in the Sacramento-San Joaquin drainage. The hardhead range extends from the Kern River to the Pit River, and they are also present in the Russian River. In the San Joaquin drainage, hardhead is scattered in tributary streams and absent from valley reaches. In the Sacramento drainage, hardhead are present mostly in the Sacramento River and larger tributary streams. They are absent in San Francisco Bay streams except the Napa River (Brown and Moyle 1993; Cooper 1983; Moyle 2002; Saiki 1984).</p> <p>Hardhead tend to be absent in streams where introduced centrarchids (sunfishes) predominate, and streams that have been severely altered by human activity (Moyle 2002).</p>	Apparently fairly common in mainstem Sacramento River, and in the lower reaches of the American and Feather Rivers (Moyle 2002).
native or introduced	If introduced, indicate timing, location, and methods.	Hardhead are native to California (Moyle 2002).	

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Element	Element Descriptor	General	Feather River Specific
ESA listing status	Following the categories according to California Code of Regulations and the Federal Register, indicate whether: SE = State-listed Endangered; ST = State-listed Threatened; FE = Federally listed Endangered; FT = Federally-listed Threatened; SCE = State Candidate (Endangered); SCT = State candidate (Threatened); FPE = Federally proposed (Endangered); FPT = Federally proposed (Threatened); FPD = Federally proposed (Delisting); the date of listing; or N = not listed.	Hardhead are not a federally or state listed species (DFG 2002).	
species status	If native, whether: Extinct/extirpated; Threatened or Endangered; Special concern; Watch list; Stable or increasing. If introduced, whether: Extirpated (failed introduction); highly localized; Localized; Widespread and stable; Widespread and expanding.	Hardhead are native to California. The overall status of hardhead is "watch list," but in the San Joaquin drainage they are a species of "special concern" (Moyle 2002). Hardhead populations are reportedly increasingly isolated from one another, making them vulnerable to localized extinctions (Moyle 2002).	
economic or recreational value	Indicate whether target species sought for food or trophy. Whether desirable by recreational fishers, commercial fishers, or both.		
warmwater or coldwater	Warmwater if suitable temperature range is similar to basses; coldwater if suitable temperature range is similar to salmonids.	Hardhead are warmwater fish (Moyle 2002). Hardhead occur in streams that reach summer water temperatures greater than 68°F (20°C) (Moyle 2002). Under laboratory conditions, their reported optimum water temperature range is 75.2°F to 82.4°F (24°C to 28°C) (Moyle 2002). Hardhead reportedly select the warmest natural	

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Element	Element Descriptor	General	Feather River Specific
		thermal plumes available [e.g., 62.6°F to 69.8°F (17°C to 21°C) in the Pit River] (Baltz et al. 1987).	
pelagic or littoral	Environment: Pelagic - living far from shore; Littoral - living near the shore.	Hardhead are freshwater fish.	
bottom or water column distribution	Environment: bottom (benthic) or along water column.	Adult hardhead reportedly often remain in the lower half of the water column (Moyle 2002; Moyle and Baltz 1985). In Britton Reservoir (Shasta County), hardhead reportedly are concentrated in surface waters less than 3.3 feet (1 m) deep, and are often seen motionless close to the surface (Moyle and Baltz 1985).	
lentic or lotic	Environment: Lentic - pertaining to stagnant water, or lake-like; Lotic - moving water, or river-like.	Hardhead are reportedly found in clear deep pools greater than 2.6 feet (80 cm) deep and in slow velocities ranging from 0.66 to 1.3 ft/sec (20 to 40 cm/sec) (Cooper 1983; Moyle 2002; Moyle and Baltz 1985). Hardhead reportedly prefer habitat that is more riverine than lacustrine (Moyle 2002).	
Adults			
life span	Approximate maximum age obtained.	Hardhead reportedly can obtain ages of more than 10 years (Moyle 2002).	In the Feather River, there are accounts of hardhead 17.3 to 18.1 inches (44-46 cm) long, at age 9 to 10 years (Moyle 2002). The Feather River fish in the 44-46 cm SL range were aged at 9-10 years, but older and larger fish reportedly probably exist in the Sacramento River (DFG 2000).
adult length	Indicate: Length at which they first reproduce; average length and maximum length the fish can	Hardhead reportedly grow to 2.3 to 3.1 inches (6 to 8 cm) in length in the first year, 3.9 to 4.7 inches (10 to 12 cm) in length in the second year, and 6.3 to	In the American River, hardhead reportedly can reach 11.8 inches (30 cm) in length

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Element	Element Descriptor	General	Feather River Specific
	attain.	6.7 inches (16 to 17 cm) in length in the third year (Moyle 2002). Hardhead reportedly mature in the third year (Moyle 2002). In small streams, hardhead reportedly rarely exceed 11 inches (28 cm) in length (Moyle 2002). Hardhead reportedly can reach lengths greater than 2 feet (60 cm) (Moyle and Baltz 1985).	at 4 years (Moyle 2002), but it reportedly takes 5 to 6 years in the Feather River to reach that length (Moyle et al. 1983). In the Feather River, hardhead ranging from 17.3 to 18.1 inches (44-46 cm) in length were reportedly 9 to 10 years of age (Moyle and Baltz 1985).
adult weight	Indicate: Weight at which they first reproduce; average weight and maximum weight the fish can attain.		
physical morphology	General shape of the fish: elongated, fusiform, laterally compressed, etc.	Hardhead resemble Sacramento pikeminnow, except the head is not as pointed, the body is slightly deeper and heavier, the maxillary bone does not reach past the front margin of the eye, and a small bridge of skin (frenum) connects the premaxillary bone to the head (Moyle 2002).	
coloration	Indicate color, and color changes, if any, during reproduction phase.	Young hardhead are silvery, and gradually turn brown to dusky bronze on the back as they mature. Breeding male hardhead develop small white tubercles that cover the snout and extend in a narrow band along the side to the base of the caudal fin (Moyle 2002).	
other physical adult descriptors	Unique physical features for easy identification.	Adult hardhead have large molariform pharyngeal teeth, while juvenile teeth are hook-like (Moyle and Baltz 1985).	
adult food base	Indicate primary diet components.	Hardhead are omnivores (Moyle 2002). They forage for benthic invertebrates, aquatic plant materials, zooplankton (in reservoirs), and drifting insects and algae (Moyle 2002). Hardhead are bottom feeders that forage for benthic invertebrates and aquatic plants (DFG 2000)	
adult feeding habits	Indicate whether plankton eater,	Hardhead are foragers and reportedly are most	

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Element	Element Descriptor	General	Feather River Specific
	algae eater, bottom feeder, piscivorous, active hunter, ambush predator, filter feeder. Night, day, dusk or dawn feeder.	active in the early morning and evening when feeding (Moyle 2002). Hardhead often swim in small groups during the day, taking insects at the surface and holding in areas of swifter current to eat insects and algae in the water column (Moyle 2002). Hardhead are considered bottom-feeders, who forage in quiet waters (Moyle and Baltz 1985).	
adult in-ocean residence time	For anadromous species, age when they migrate to the ocean and duration spent in the ocean before returning to freshwater to spawn.		
adult habitat characteristics in-ocean	For anadromous species, description of the ocean habitat utilized: whether along major current systems, gyres, pelagic (beyond continental shelves) and neritic (above continental shelves) zones, etc.		
Adult upstream migration (immigration)			
range of adult upstream migration timing	Time of year adults migrate upstream. If applicable, indicate for various runs.	Hardhead from large rivers or reservoirs reportedly may migrate 18.6 to 46.6 miles (30 to 75+ km) upstream in April and May, usually in tributary streams (Moyle 2002). In small streams, hardhead reportedly may only move a short distance from their home pools for spawning, either upstream or downstream (Moyle 2002).	
peak adult upstream migration timing	Time of year most adults migrate upstream. If applicable, indicate for various runs.		
adult upstream migration water temperature tolerance	Range of water temperatures allowing survival. Indicate stressful or lethal levels.		

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Element	Element Descriptor	General	Feather River Specific
adult upstream migration water temperature preference	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental.	Using samples of hardhead taken at ten locations within water bodies of the San Joaquin drainage, it was determined that adults prefer water temperatures of 68°F (20°C) (Brown and Moyle 1993).	
Adult holding (freshwater residence)			
water temperature tolerance for holding adults	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	Most streams hardhead inhabit have summer water temperatures greater than 68°F (20°C) (Moyle and Baltz 1985).	
water temperature preference for holding adults	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental.	The preferred water temperature for hardhead, as observed under laboratory conditions, ranged from 75.2°F to 82.4°F (24°C to 28°C) (Moyle 2002). Hardhead reportedly selected water temperatures of 62.6°F to 69.8°F (17°C to 21°C) in the Pit River (Baltz et al. 1987).	
water depth range for holding adults	Reported range of observed (minimum and maximum) water depth utilization.	In streams, adult hardhead reportedly often remain in the lower half of the water column, although in reservoirs they can occasionally be seen hovering close to the surface (Moyle 2002). The reported range of observed (minimum and maximum) water depth utilization was 35.5 to 107.7 cm (13.9 to 42.4 in) (Moyle and Baltz 1985).	
water depth preference for holding adults	Reported range of most frequently observed water depth utilization.	Hardhead are reportedly found in Deer Creek in pools and runs ranging in depth from 15.7 to 55.1 inches (40 to 140 cm) deep (Moyle and Baltz 1985). Hardhead reportedly prefer water depths greater than 31.5 inches (80 cm) (Moyle 2002).	
substrate preference for holding adults	If bottom dwellers, indicate substrate: mud, sand, gravel, boulders, aquatic plant beds, etc. If gravel, indicate range or average size of gravel.	Substrates preferred by hardhead include sand, gravel, and boulders (Cooper 1983).	
water velocity range for holding adults	Reported range of observed (minimum and maximum) water velocity utilization.	Hardhead reportedly prefer velocities ranging from 0.66 to 1.3 ft/sec (20 to 40 cm/sec) (Cooper 1983).	

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Element	Element Descriptor	General	Feather River Specific
		Hardhead reportedly prefer velocities ranging from 0 to 0.98 ft/s (0 to 30 cm/sec) (Moyle and Baltz 1985).	
water velocity preference for holding adults	Reported range of most frequently observed water velocity utilization.	Hardhead reportedly prefer water velocities less than 0.82 ft/sec (25 cm/sec) (Moyle and Baltz 1985).	
other habitat characteristics for holding adults	General description of habitat (e.g. turbid or clear waters, lentic or lotic, presence of aquatic plant beds, debris, cover, etc.).	Hardhead habitat is reportedly more riverine than lacustrine (Moyle 2002). Hardhead reportedly prefer clear pools and runs with sand, gravel, and/or boulder substrates (Moyle 2002). Hardhead are reportedly found in undisturbed areas of middle- and low-elevation streams, with elevation ranges of 32.8 to 4,757 ft (10 to 1,450 m) (Moyle and Baltz 1985).	
timing range for adult holding	Time of year (earliest-latest) and duration of stay from upstream migration to spawning.		
timing peak for adult holding	Time of year when maximum number of adults are present before spawning.		
Spawning			
fecundity	Average or range in the number of eggs females lay in a spawning season.	Female hardhead reportedly can produce 7,000 to 24,000 eggs, depending on fish size (Moyle 2002). Over 20,000 eggs can be produced by one female hardhead, however, 9,500 to 10,700 eggs per female has also been reported (Moyle and Baltz 1985).	
nest construction	Location and general description of nest -- substrates, aquatic plants, excavations, crevices, habitat types, etc.		
nest size	Size and average dimensions of the nest.		

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Element	Element Descriptor	General	Feather River Specific
spawning process	Indicate whether nest builder, broadcast spawner, or other.	The hardhead spawning process has not been observed; however, it is believed to be similar to that of hitch and pikeminnow, in that their fertilized eggs are deposited on beds of gravel in riffles, runs, or heads of pools (Moyle 2002). Mass spawning of hardhead reportedly takes place in upstream gravel riffles (Moyle and Baltz 1985).	
spawning substrate size/characteristics	Range of substrates used during spawning (e.g., mud, sand, gravel, boulders, beds of aquatic plants). Indicate presence of plant/wood debris, crevices at spawning sites. If gravel, indicate range of average size.	Hardhead eggs reportedly are deposited in gravel riffles, runs, or heads of pools (Moyle 2002). Hardhead eggs are reportedly deposited in sand, gravel, and decomposed granite and rocky areas (Wang 1986).	
preferred spawning substrate	Indicate preferred spawning substrate (e.g., mud, sand, gravel, boulders, plant bed, etc).	Substrates used during hardhead spawning reportedly include gravel, sand, decomposed granite, and rocky areas (Wang 1986).	
water temperature tolerance for spawning	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	Hardhead were reportedly observed spawning in Pine Creek at water temperatures ranging from 55.4°F to 68°F (13°C to 20°C) (Moyle 2002).	
water temperature preference for spawning	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.	Temperatures for hardhead spawning reportedly range from 59°F to 64.4°F (15°C to 18°C) (Wang 1986).	
water velocity range for spawning	Minimum and maximum speed of water current the spawning fish can tolerate.		
water velocity preference for spawning	Preferred water current (flow velocity) during spawning.	Reproductive behavior presumably involves mass spawning in upstream gravel riffles (Moyle 1976 <i>in</i> (DFG 2000).	
water depth range for spawning	Reported range of observed (minimum and maximum) water depth utilization.		
water depth preference for spawning	Reported range of most frequently observed water depth		

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Element	Element Descriptor	General	Feather River Specific
	utilization.		
range for spawning timing	Earliest and latest time of season or year in which spawning occurs.	Juvenile hardhead recruitment patterns suggest spawning may extend into August in foothill streams of the Sacramento-San Joaquin drainage (Wang 1986). Juvenile recruitment suggest that hardhead spawn May-June in Central Valley streams, but the spawning season may extend into August in the foothill streams of the Sacramento-San Joaquin drainage (DFG 2000).	
peak spawning timing	Time of year most fish start to spawn.	Most hardhead reportedly spawn in the April through May period (Moyle 2002).	
spawning frequency (iteroparous/semelparous)	Semelparous - producing all offspring at one time, such as in most salmon. Usually these fish die after reproduction. Iteroparous - producing offspring in successive, e.g., annual or seasonal batches, as is the case in most fishes.	Hardhead spawn annually (Moyle 2002).	
Incubation/early development			
egg characteristics	Shape, size, color, in clusters or individuals, stickiness, and other physical attributes.	Hardhead eggs are spherical (Wang 1986).	
water temperature tolerance for incubation	Range of water temperatures allowing survival. Indicate stressful or lethal levels.		
water temperature preference for incubation	Range of suitable, preferred or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.		
time required for incubation	Time duration from fertilization to hatching. Note: Indicate at which temperature range. Incubation time is temperature-dependent.		

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Element	Element Descriptor	General	Feather River Specific
size of newly hatched larvae	Average size of newly hatched larvae.	60 to 65% of post larvae hardhead were reportedly 11.3 to 16.5 mm TL (Wang 1986).	
time newly hatched larvae remain in gravel	Time of year of hatching, and duration between hatching and emergence from gravel.		
other characteristics of larvae	Alevin -- early life history phase just after hatching (larva) when yolk-sac still present.	Larvae and post-larvae hardhead probably remain along the stream edges in dense cover of flooded vegetation or fallen tree branches. As they grow, they move into deeper habitats (Moyle 2002).	
timing range for emergence	Time of year (earliest-latest) hatchlings (larvae and alevins) leave or emerge from the nesting/hatching (gravel) sites.		
timing peak for emergence	Time of year most hatchlings emerge.		
size at emergence from gravel	Average size of hatchlings at time of emergence.		
Juvenile rearing			
general rearing habitat and strategies	General description of freshwater environment and rearing behavior.	Juveniles reportedly concentrate in shallow water close to the edges (DFG 2000). Smaller fish (<20 cm SL) reportedly feed primarily on mayfly larvae, caddisfly larvae, and small snails (Reeves 1964 in (DFG 2000)).	
water temperature tolerance for juvenile rearing	Range of water temperatures allowing survival. Indicate stressful or lethal levels.	Juvenile hardhead may be found in various temperature gradients, such as in Millerton Lake (Wang 1986). Water temperatures where juveniles and adults were observed in the Pit River ranged from 61.8°F to 68.4°F (16.6°C to 20.2°C) (Baltz et al. 1987).	
water temperature preference for juvenile rearing	Range of suitable, preferred, or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.		

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water velocity ranges for rearing juveniles	Reported range of observed (minimum and maximum) water velocity utilization.	In Deer Creek, hardhead measuring 0.78 to 1.9 inches (2 to 5 cm) in length select habitats with water column velocities of 0 to 0.98 ft/s (0 to 30 cm/s) (Moyle 2002). The reported range of observed (minimum and maximum) water velocity utilization is 15.8 to 17.0 cm/s (Moyle and Baltz 1985).	
water velocities preferred by rearing juveniles	Reported range of most frequently observed water velocity utilization.	Water diversion approach velocities reportedly should not exceed 0.4 m/s (Myrick and Cech Jr. 2000).	
water depth range for juvenile rearing	Reported range of observed (minimum and maximum) water depth utilization.	Juvenile hardhead reportedly concentrate in shallow water close to stream edges; however, in Britton Reservoir and in the Pit River system, hardhead reportedly are found close to the surface (Moyle and Baltz 1985). The reported range of observed (minimum and maximum) water depth utilization is 32.1 to 91.2 cm (12.6 to 35.9 in) (Moyle and Baltz 1985).	
water depth preference for juvenile rearing	Reported range of most frequently observed water depth utilization.	The deeper parts of the stream were reportedly favored by juvenile and adult hardhead (Moyle and Baltz 1985).	
cover preferences for rearing juveniles	Type of cover for protection from predators used by rearing juveniles (e.g. crevices, submerged aquatic vegetation, overhanging vegetation, substrate cover, undercover bank, small woody debris, large woody debris).	After hatching, larval and post-larval hardhead presumably remain along stream edges in dense cover of flooded vegetation or fallen tree branches. As they grow, they move to deeper habitats. Small juvenile hardhead may concentrate along stream edges among large cobbles and boulders. At 0.8 to 2 inches (2 to 5 cm), hardhead select habitats similar to adults (Moyle 2002).	
food base of juveniles	Indicate primary diet components. Also indicate the diet changes, if any, as growth occurs.	Smaller hardhead [less than 7.9 inches (0 cm) in length] reportedly eat mayfly larvae, caddisfly larvae, and small snails. Larger hardhead may feed on aquatic plants, especially filamentous algae, crayfish, and large invertebrates (Moyle 2002).	

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feeding habits of rearing juveniles	Indicate whether plankton eater, algae eater, bottom feeder, piscivorous, active hunter, ambush predator, filter feeder. Night, day, dusk or dawn feeder. Also indicate change of feeding habits growth occurs.	Juvenile hardhead reportedly feed on plankton and cladocerans (Wales 1946) and on insects and small snails (Reeves 1964). Juvenile hardhead also may take filamentous algae in the intermittent pools of the upper San Joaquin River, particularly in the fall months (Wang 1986).	
predation of juveniles	Indicate which species prey on juveniles.	Bald eagles prey on juvenile hardhead (Moyle 2002).	
timing range for juvenile rearing	Range of time of year (months) during which rearing occurs.		
timing peak for juvenile rearing	Time of year (months) during which most rearing occurs.		
Juvenile emigration			
general rearing habitat and strategies	General description of freshwater environment and rearing behavior.		
water temperature tolerance for juvenile rearing	Range of water temperatures allowing survival. Indicate stressful or lethal levels.		
water temperature preference for juvenile rearing	Range of suitable, preferred, or reported optimal water temperatures. Indicate whether literature, observational, or experimental derivation.		
water velocity ranges for rearing juveniles	Reported range of observed (minimum and maximum) water velocity utilization.		
water velocities preferred by rearing juveniles	Reported range of most frequently observed water velocity utilization.		
water depth range for juvenile rearing	Reported range of observed (minimum and maximum) water depth utilization.		
water depth preference for juvenile rearing	Reported range of most frequently observed water depth utilization.		

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Element	Element Descriptor	General	Feather River Specific
Other potential factors			
DO	Levels of dissolved oxygen in water expressed in mg/l tolerated by fish.	At high water temperatures, hardhead are relatively intolerant of low oxygen levels (Moyle 2002). Cech et al. (1990) demonstrated that hardhead are intolerant of low oxygen levels, especially at higher temperatures (DFG 2000).	
pH	Alkalinity/acidity of water (expressed in pH) that fish can tolerate.	In general, the threshold for cyprinids is reportedly between pH 5.5 and 6.0; however, this varies whenever cyprinids are examined individually (Baker et al. 1990 <i>in</i> (Pinder and Morgan 1995).	
turbidity	Indicate turbidity or state of water (e.g., clear water or presence of siltation or organic/inorganic matter in water) that fish can tolerate.	Hardhead reportedly prefer clear and deep pools (Moyle 2002).	
factors contributing to mortality	e.g. fishing/angling mortality, drastic habitat alterations, unfavorable climatic changes, etc.	The cause of the hardhead decline appears to be habitat loss and predation by non-native fishes (Moyle 2002). Hardhead reportedly are found in fewer locations than in 1970. The decline in hardhead is reportedly associated with the expansion of smallmouth bass (Brown and Moyle 1993). In 1978, hardhead in the Pit River were reportedly found only in the undisturbed upper reaches (Cooper 1983). Specialized habitat requirements combined with widespread alteration of downstream habitats may have resulted in localized, isolated populations of hardhead (Moyle and Baltz 1985).	

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